



C/NOFS Press Conference

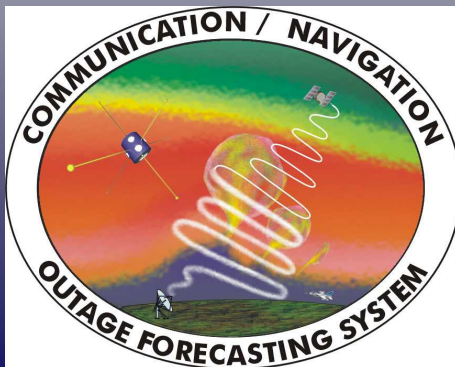
AGU 15 December 2008

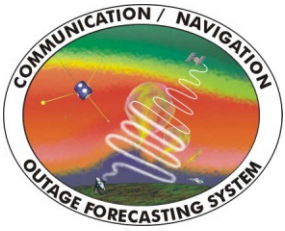
Don Hunton and Odile de La Beaujardière

Air Force Research Laboratory Space Vehicles Directorate

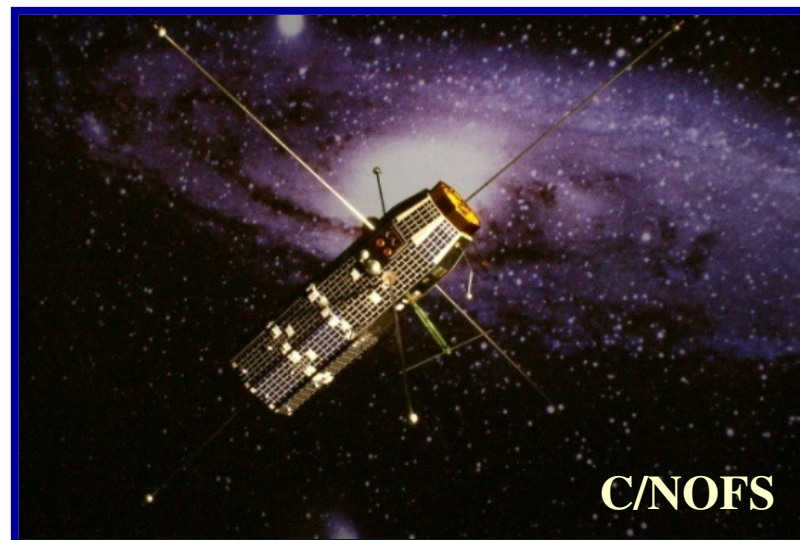
Rod Heelis, The University of Texas at Dallas

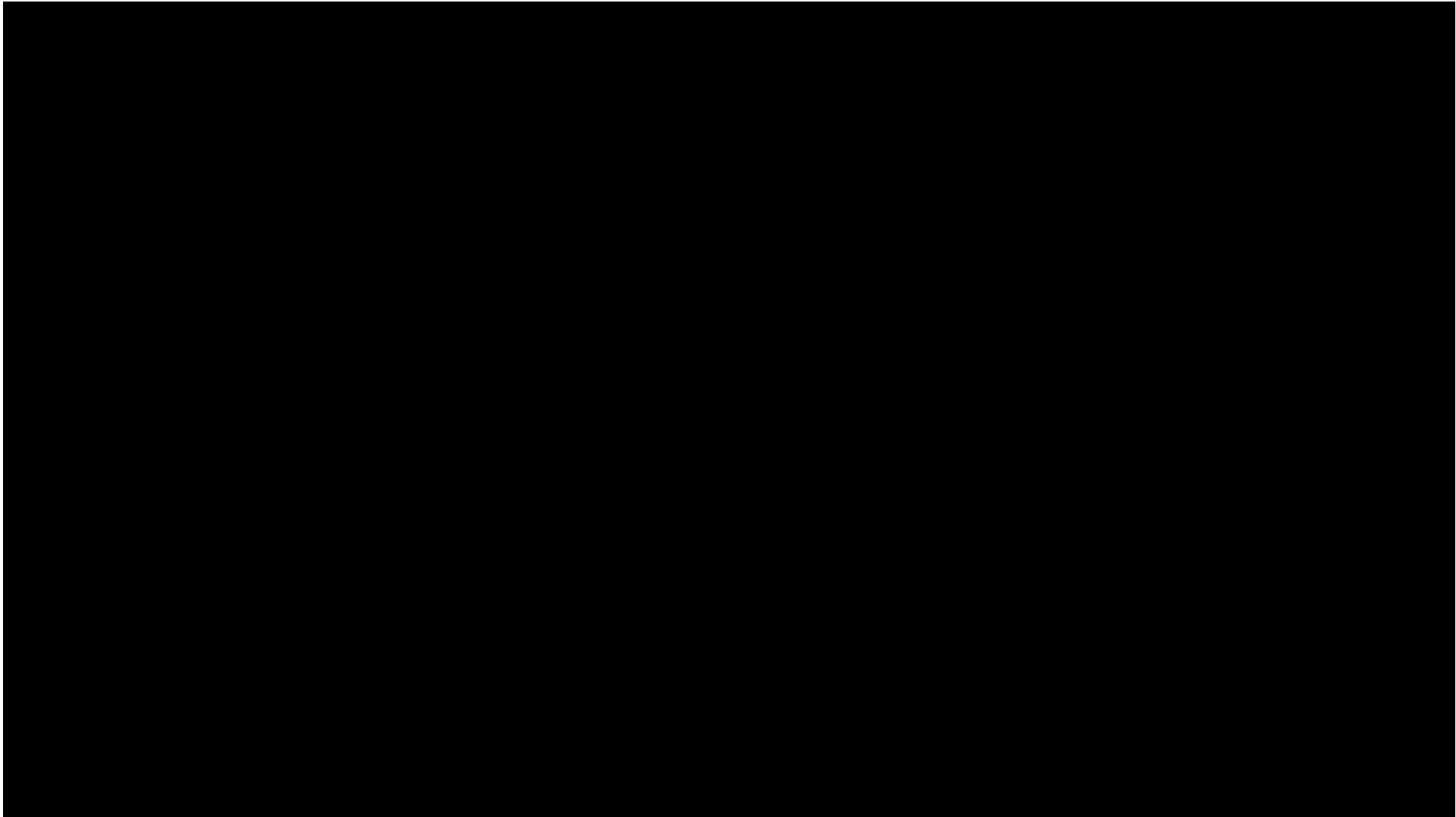
Rob Pfaff, NASA Goddard Space Flight Center





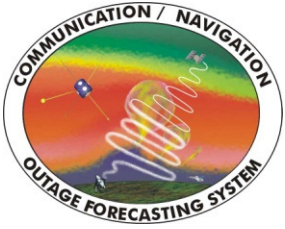
Dr. Donald Hunton
C/NOFS Technical Manager
Air Force Research Laboratory
Space Vehicles Directorate





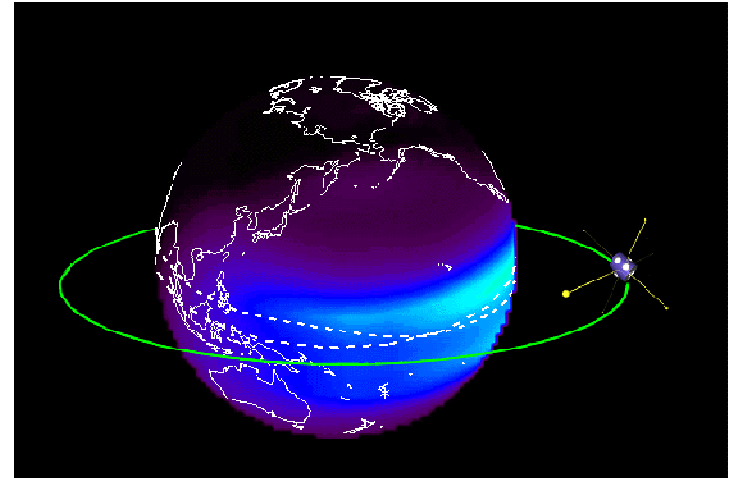
Communication/Navigation Outage Forecasting System

[NASA animation]

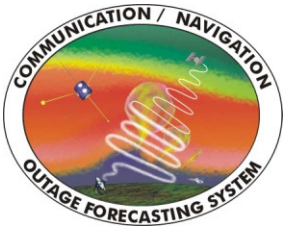


C/NOFS Communication

- **Communication**
- **Navigation**
- **Outage**
- **Forecasting**
- **System**

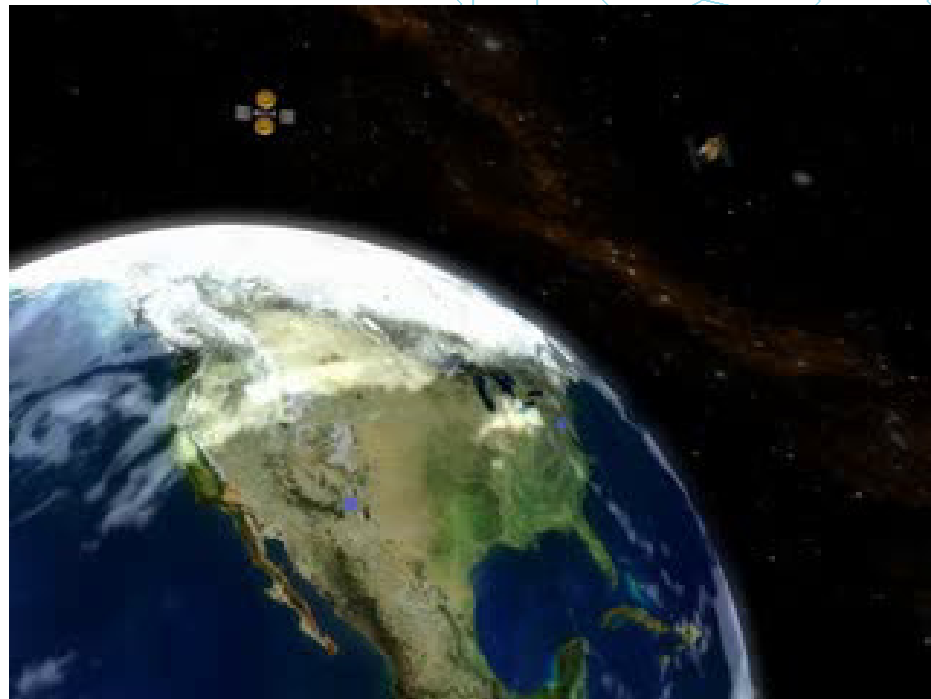
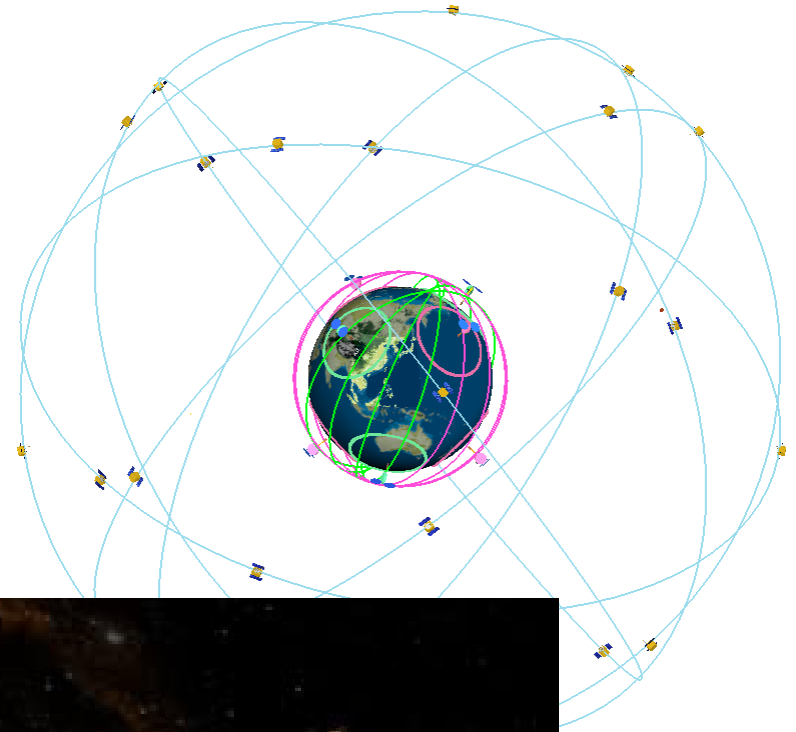


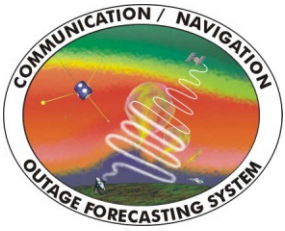
QuickTime™ and a
H.264 decompressor
are needed to see this picture.



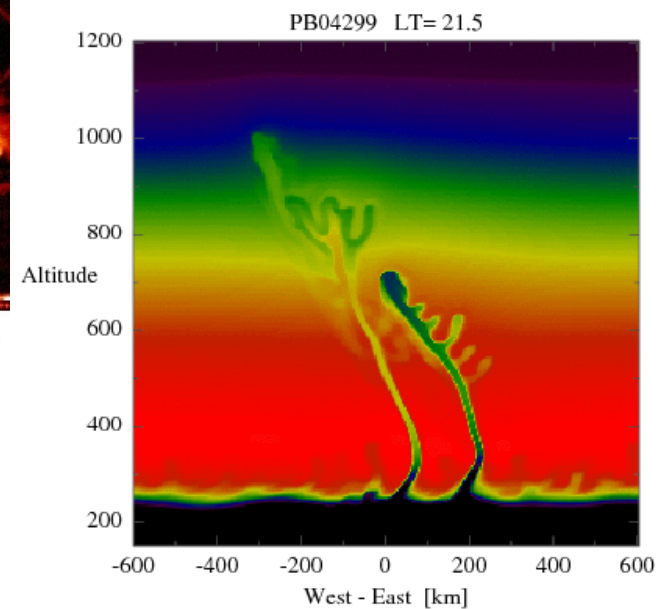
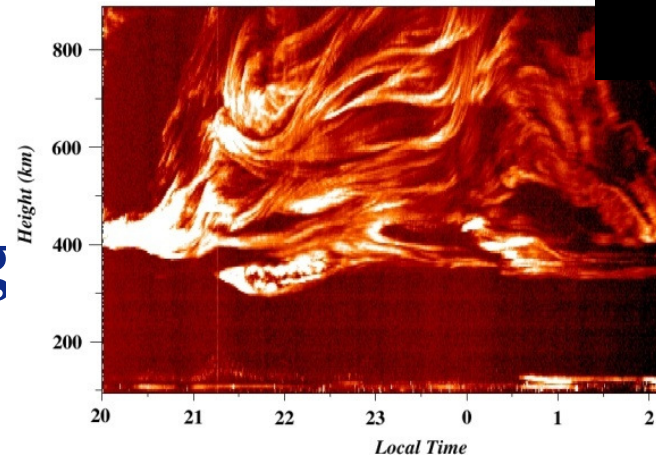
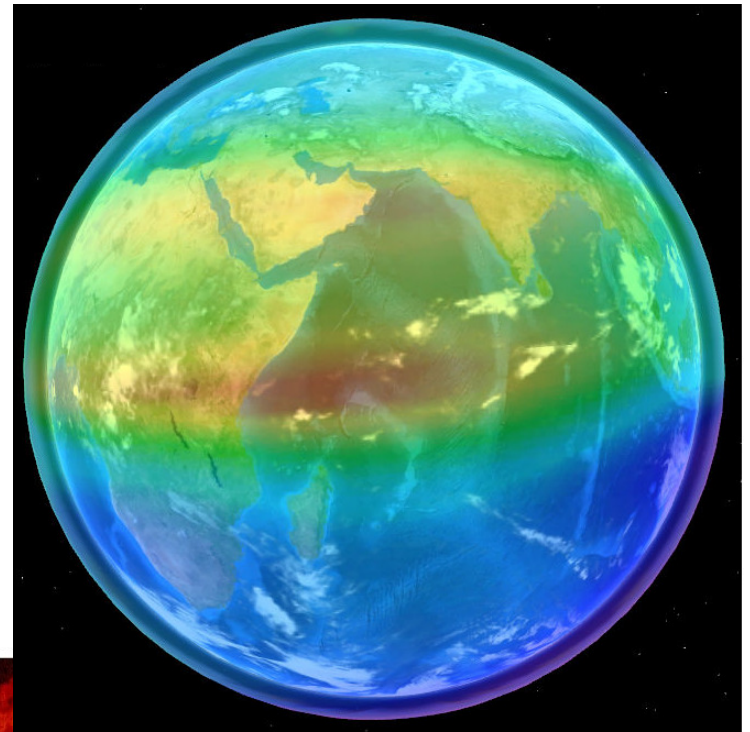
C/NOFS Navigation

- **Communication**
- **Navigation**
- **Outage**
- **Forecasting**
- **System**





- Communication
- Navigation
- Outage
- Forecasting
- System



Ionospheric Scintillation

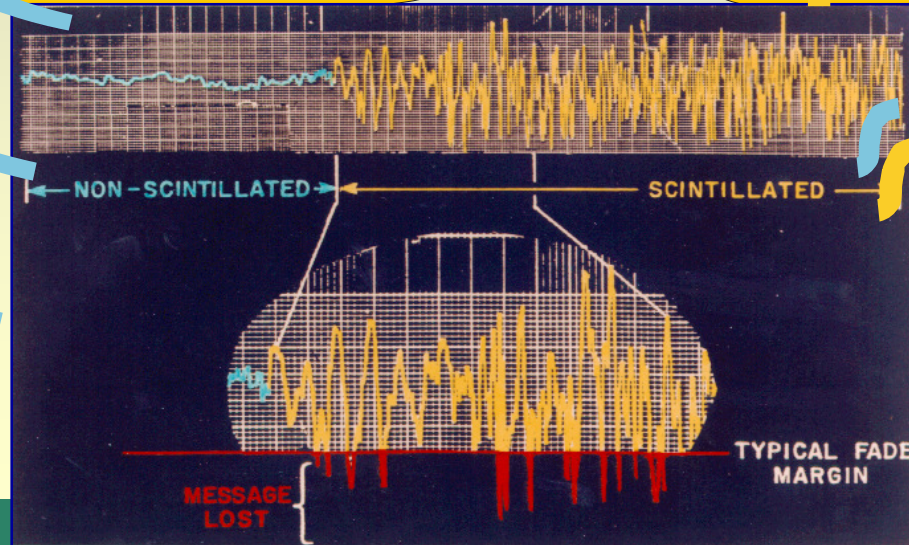
Variations in signal amplitude and phase caused by irregularities in ionosphere

Undisturbed Ionosphere

Disturbed Ionosphere:

- Bubbles
- Plumes
- Spread-F
- Plasma instabilities

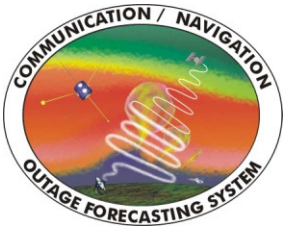
Clear Reception



Signal Interference

- Distortion
- Fade
- Dropouts, signal loss

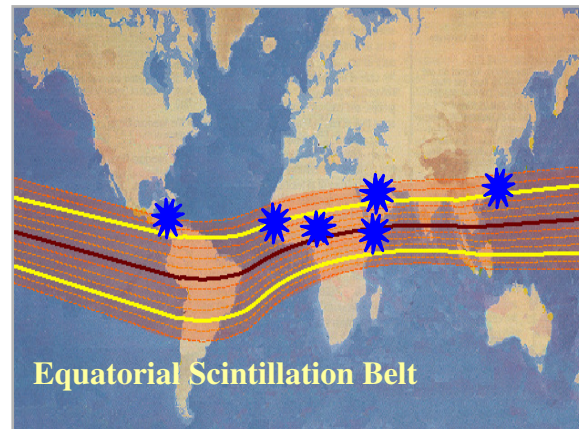




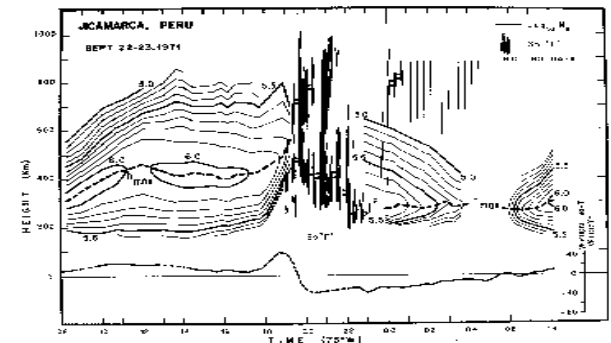
C/NOFS Forecasting

Probability of scintillation, on average,
is known as a function of...

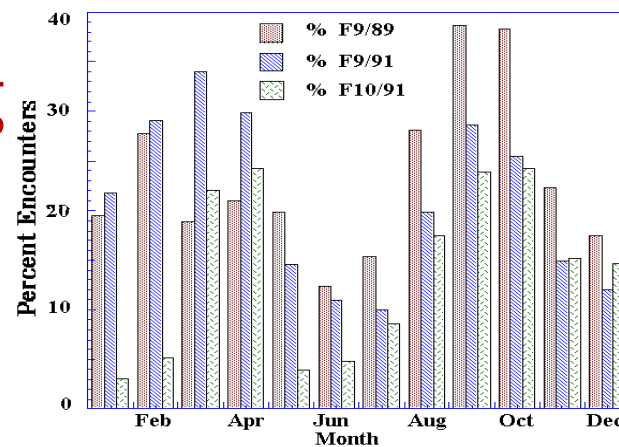
- Communication
- Navigation
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- System



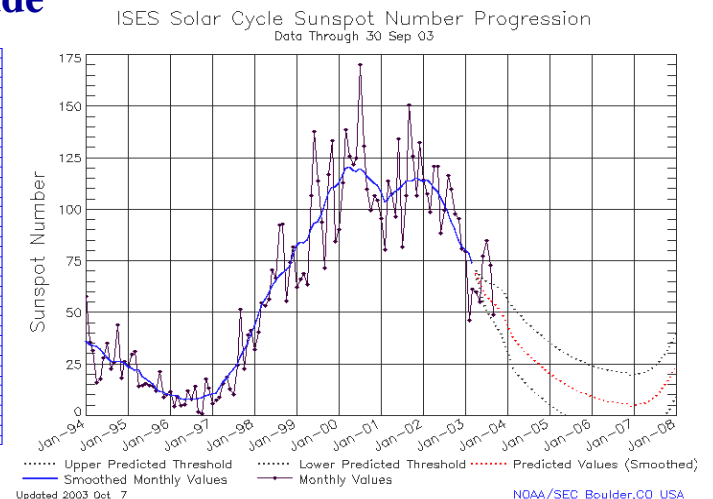
Magnetic Latitude & Longitude



Time of Day

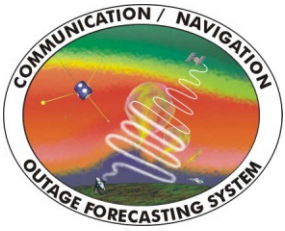


Time of Year



Solar Cycle

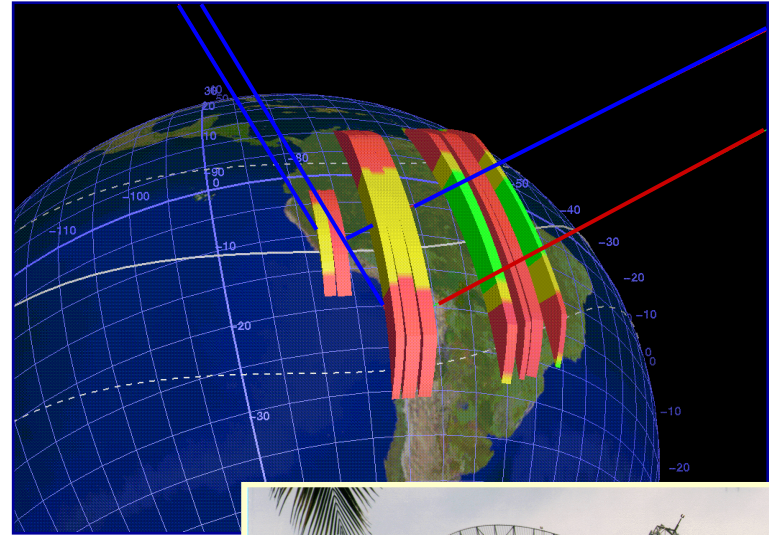
NOAA/SEC Boulder, CO USA



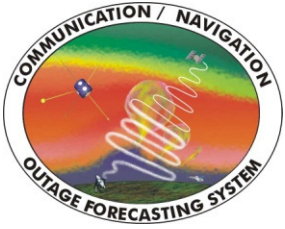
C/NOFS Forecasting

But ...

“Will scintillation
impact my operations
tonight?”



C/NOFS seeks to make the leap
from climate to true forecasting



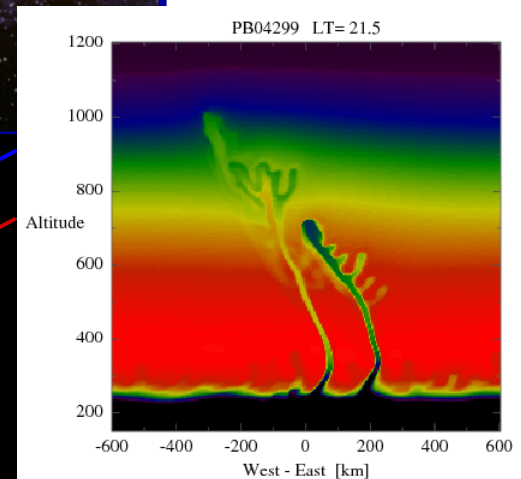
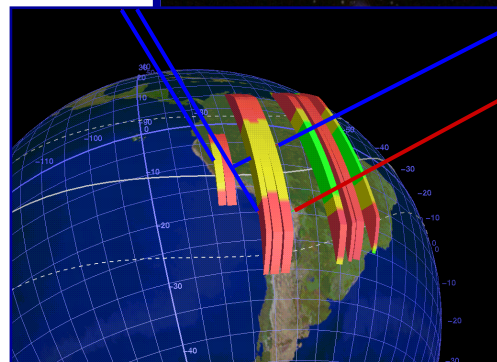
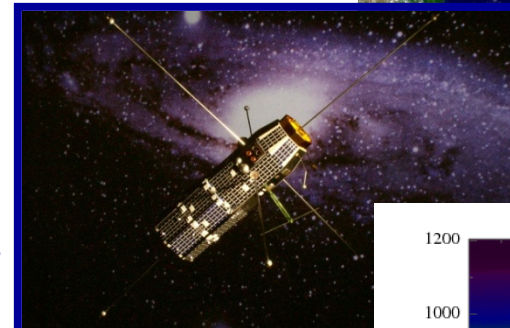
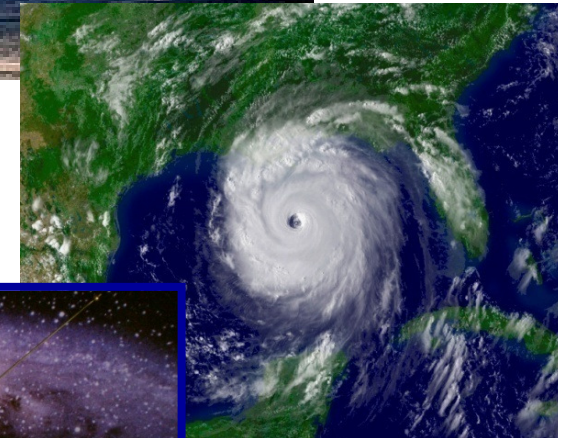
Weather vs “Space Weather”

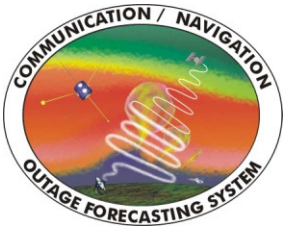
The C/NOFS approach is similar to terrestrial weather forecasting.

Meteorologists have satellite and ground-based observations which serve as input to computer models that provide forecasts of weather conditions several days ahead.

For the first time ever we have the C/NOFS satellite, ground-based sensors, and complex computer models all focused on the ionosphere.

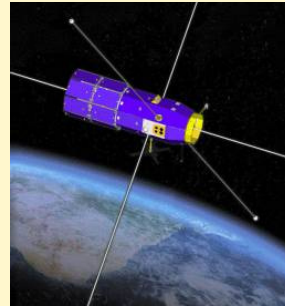
With C/NOFS, scientists have the capability to generate the first “space weather” forecasts.



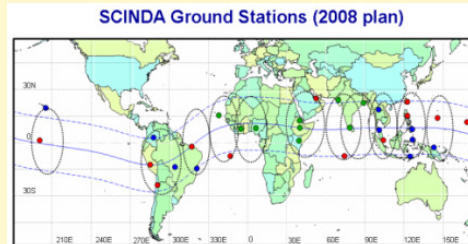
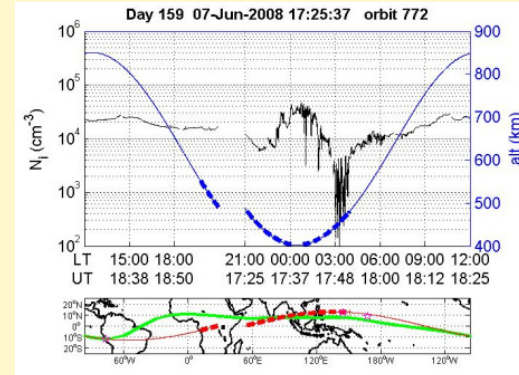


C/NOFS is more than just a satellite!

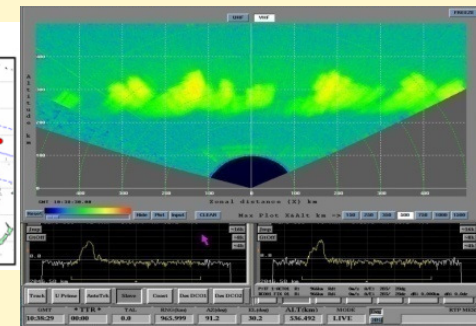
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Space Segment

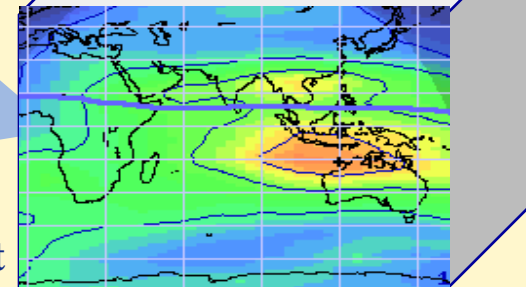


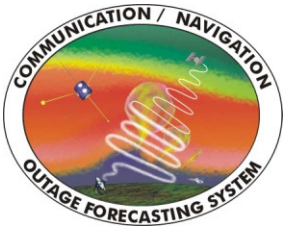
Ground Segment



Data/Model Segment

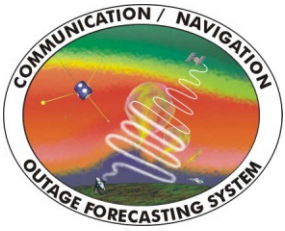
4-D Data Cube





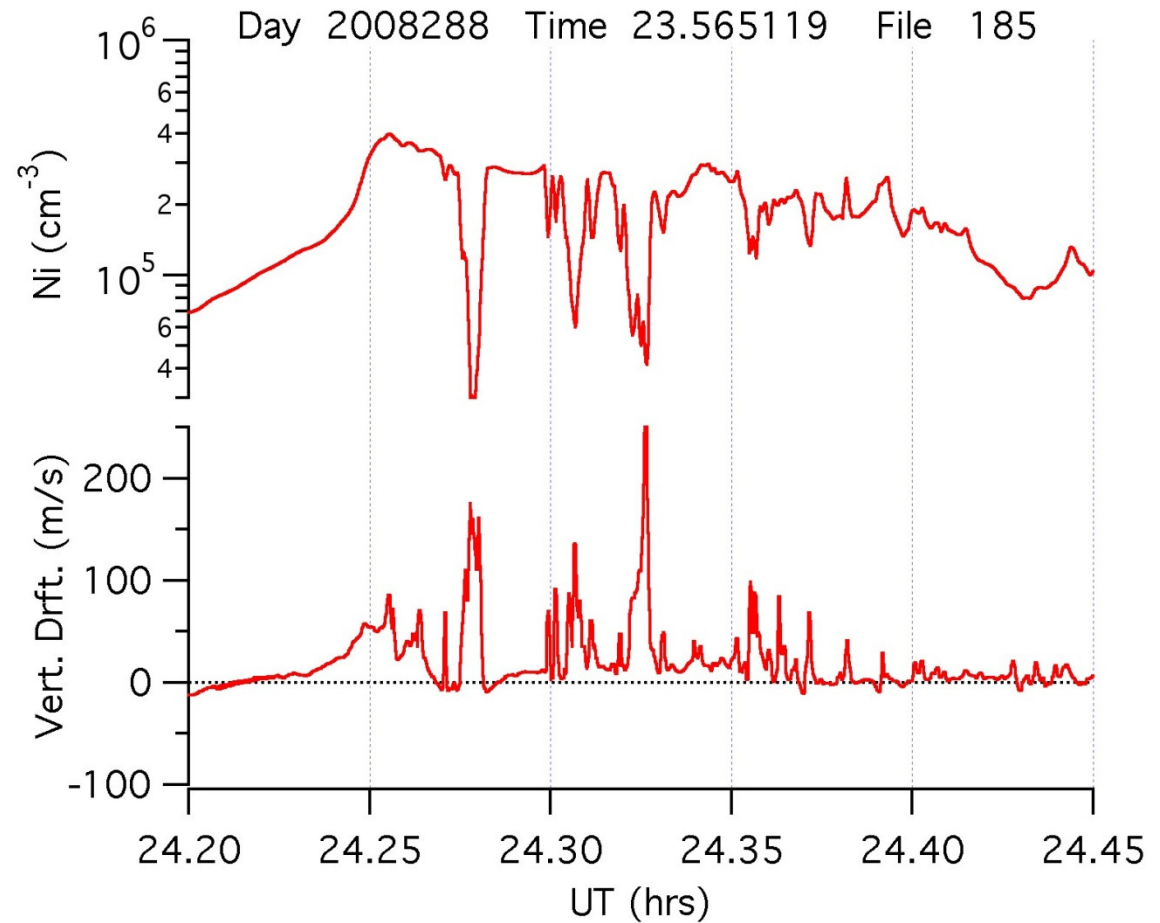
Dr. Odile de La Beaujardière
C/NOFS Science Principal Investigator
Air Force Research Laboratory
Space Vehicles Directorate





C/NOFS Observations of Ionospheric Structures

Plasma densities (top) and vertical drifts (bottom) observed on 14 Oct 2008 as the C/NOFS satellite flew through the disturbed ionosphere.

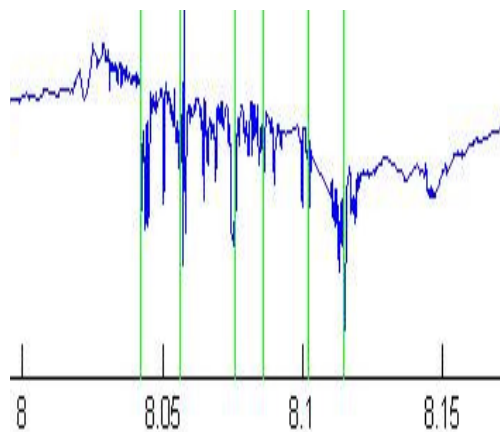


Ionosphere at solar minimum is highly structured and easily perturbed.

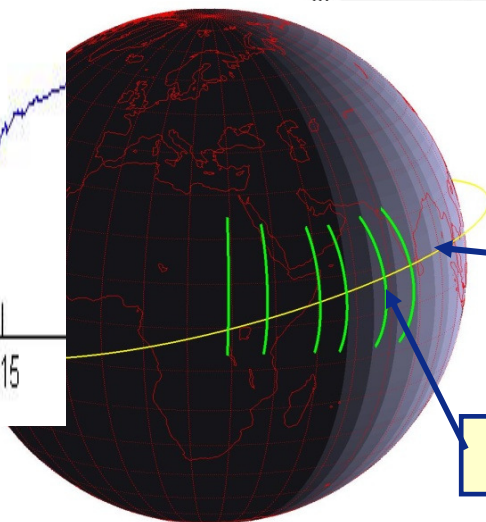


Irregularities Appear After Midnight

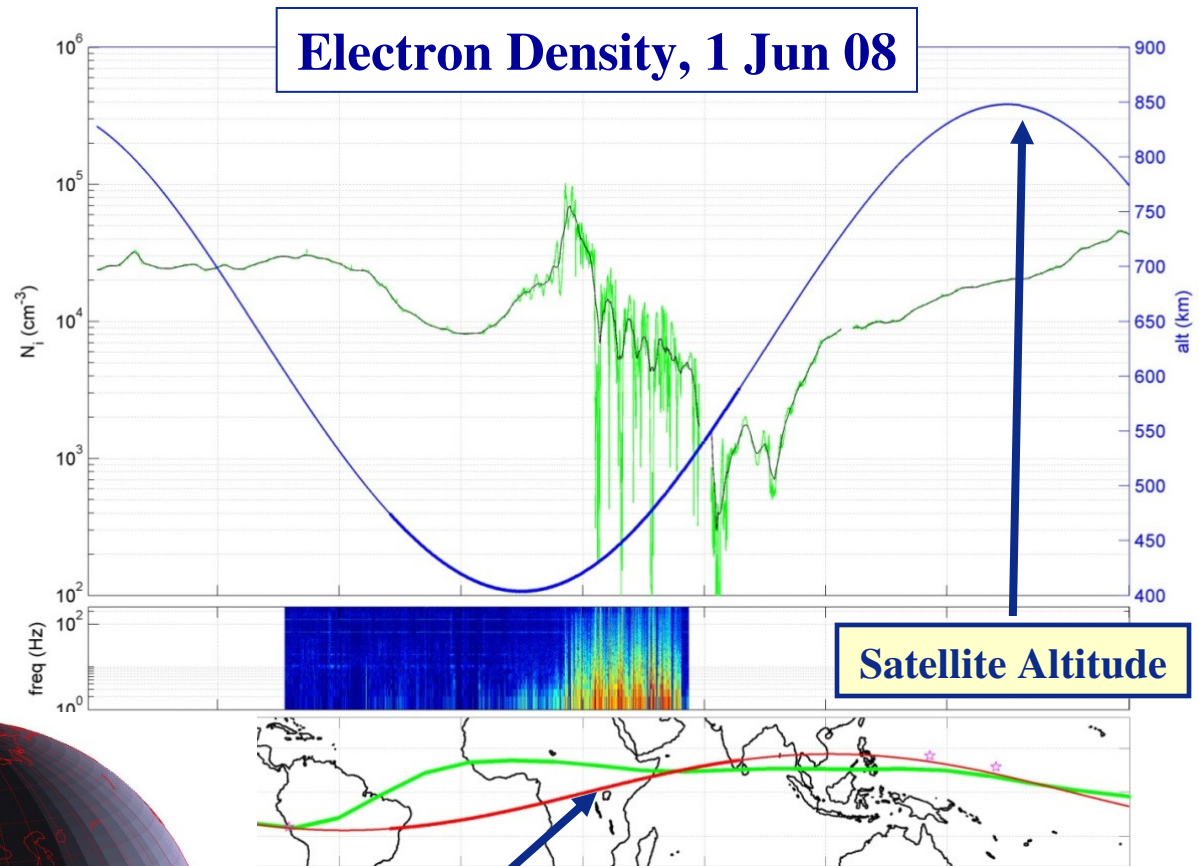
- Plasma bubbles form after midnight
- Appear most intense above Africa
- Bubbles elongated along Earth's magnetic field lines

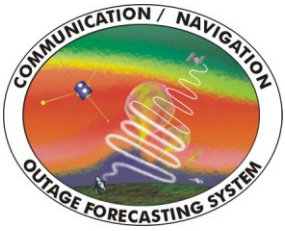


Longitude



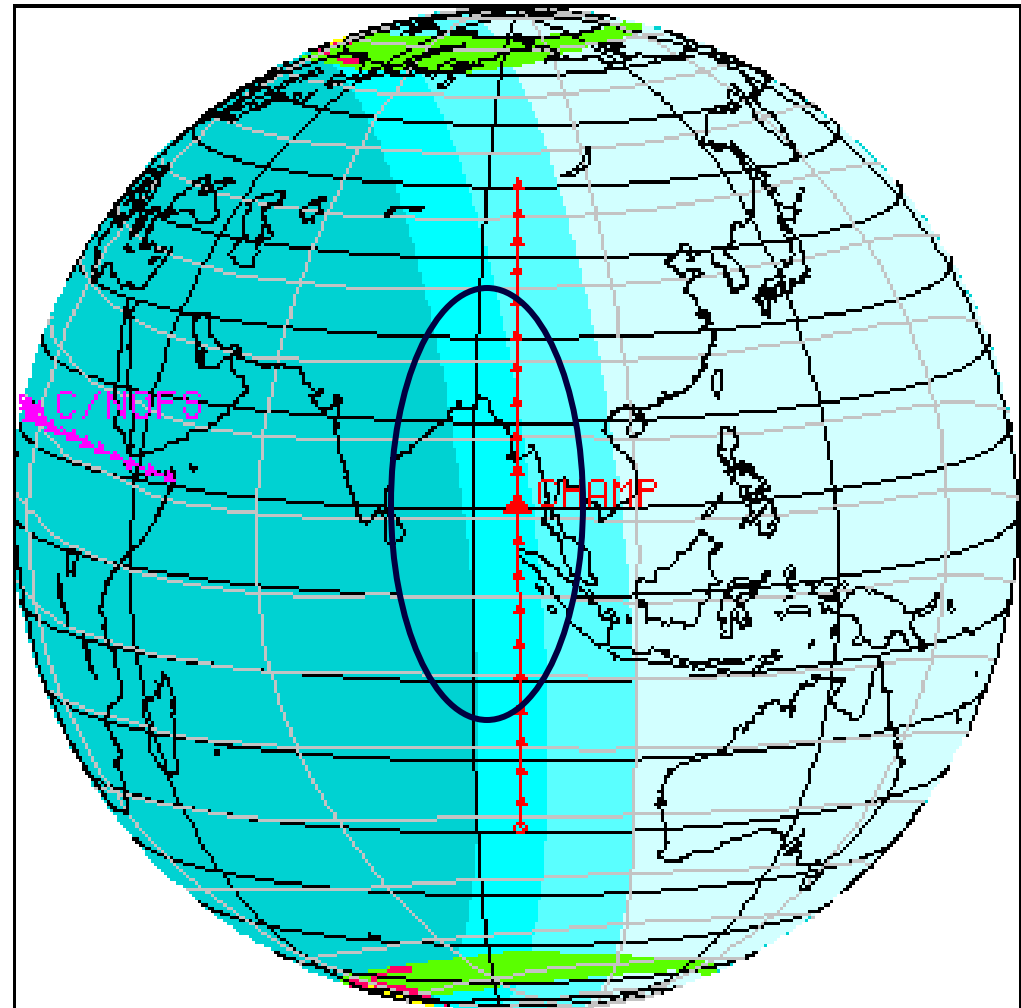
Magnetic Field Lines

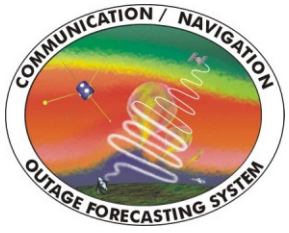


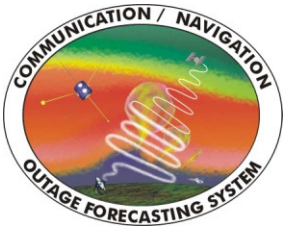


Dawn Depletion Seen by CHAMP and C/NOFS

- Upper atmosphere is still in darkness, but the sun will hit it very soon
- Dawn depletions are like a funnel moving around the Earth as the sun rises
- They are roughly 50° by 20° in the N-S and E-W directions, respectively

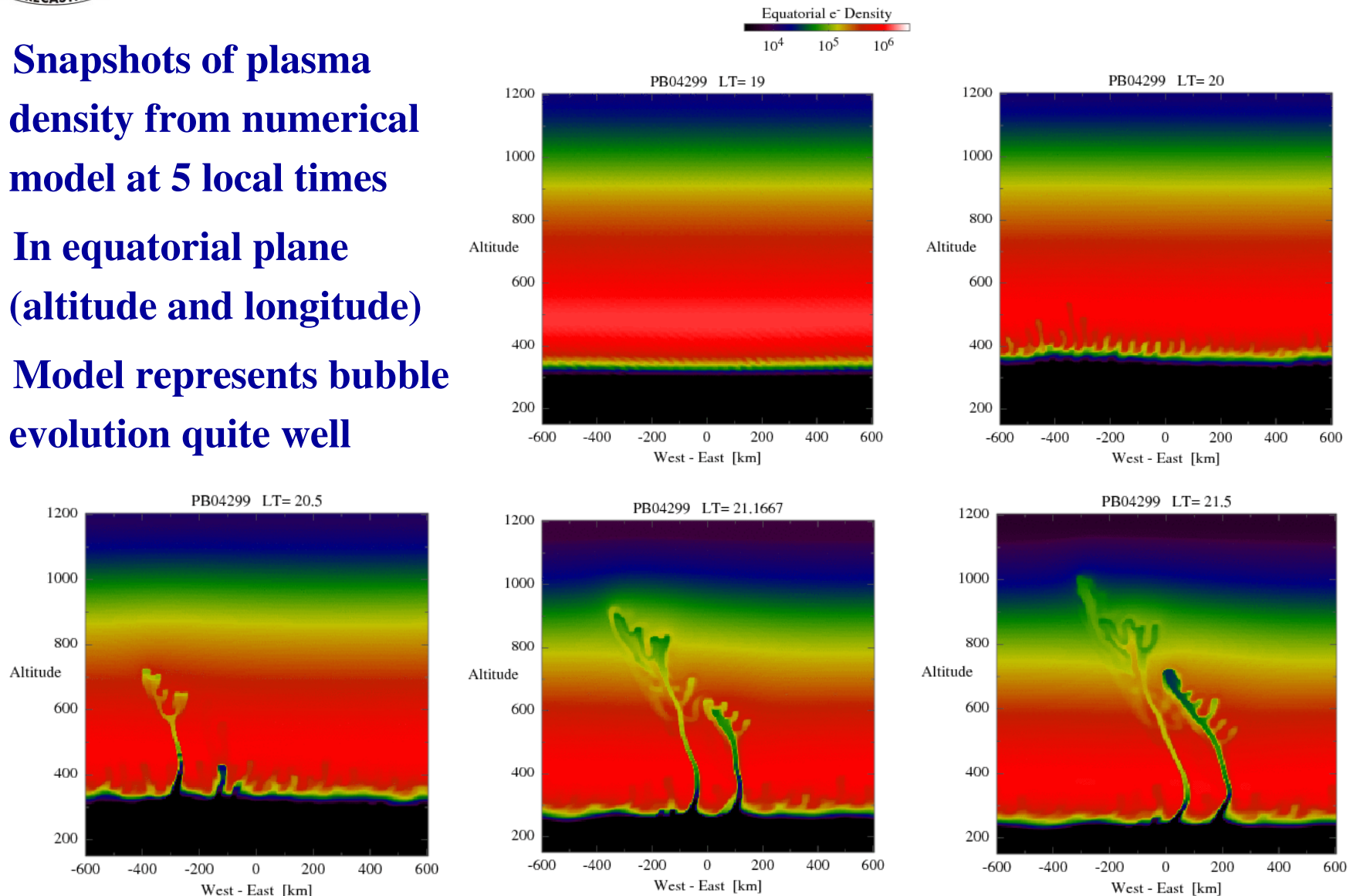


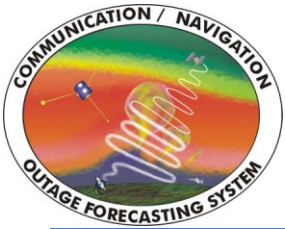




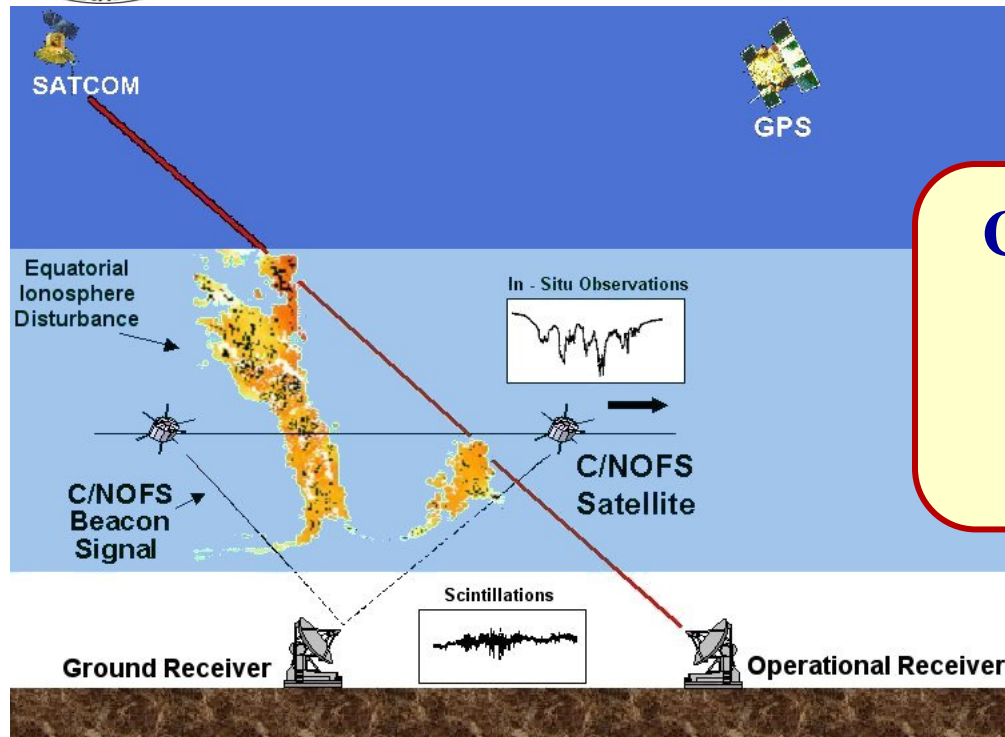
Birth and Growth of Equatorial Bubbles

- Snapshots of plasma density from numerical model at 5 local times
- In equatorial plane (altitude and longitude)
- Model represents bubble evolution quite well



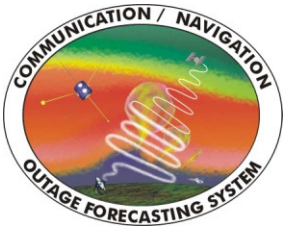


C/NOFS Mission Goals



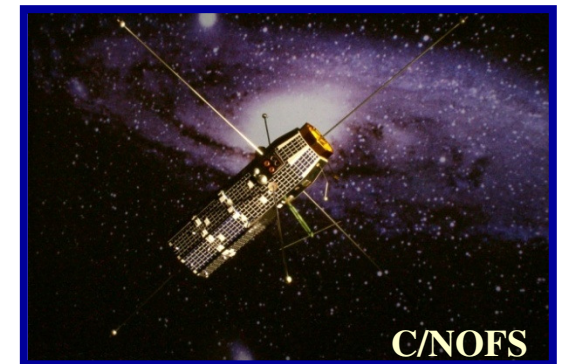
C/NOFS is the first mission fully equipped to forecast the “weather” of the ionosphere.

1. Nowcast and forecast ionospheric electron density and presence of irregularities
 - Irregularities and scintillation are mostly quiet time phenomena
 - Regularly occur when there are no magnetic storms
 - Challenge: to forecast ionospheric conditions when the Sun is quiet!
2. Develop capability to produce 2 to 5 day forecasts
3. Improve understanding of equatorial ionosphere structure and dynamics
4. Determine parameters that trigger and suppress irregularities

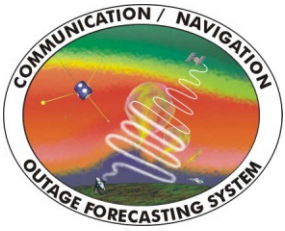


Communication / Navigation Outage Forecasting System

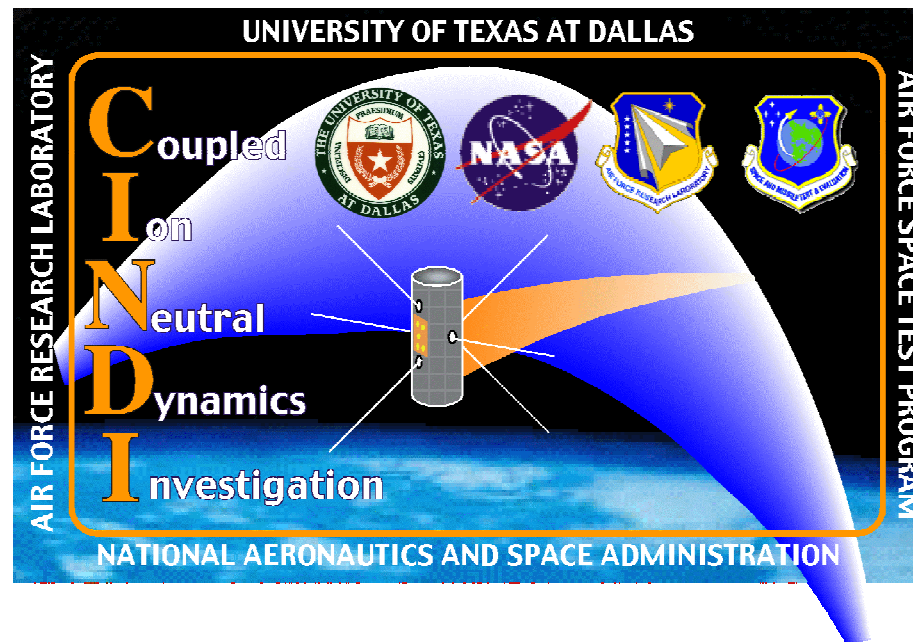
- **C/NOFS**
 - Spacecraft instruments, ground-based sensors, integrated models focused on the ionosphere to forecast conditions that degrade RF communication and GPS navigation signals.
- **C/NOFS results unlock some mysteries and present others.**
 - Solar minimum ionosphere is highly structured.
 - Irregularities are observed after midnight and before sunrise as well as in the early evening.
 - Electron densities are ~ 10 times lower than most models predicted even for solar minimum.
- **More “space weather” forecasting challenges lie ahead.**



It does not take a solar storm to disturb the ionosphere!

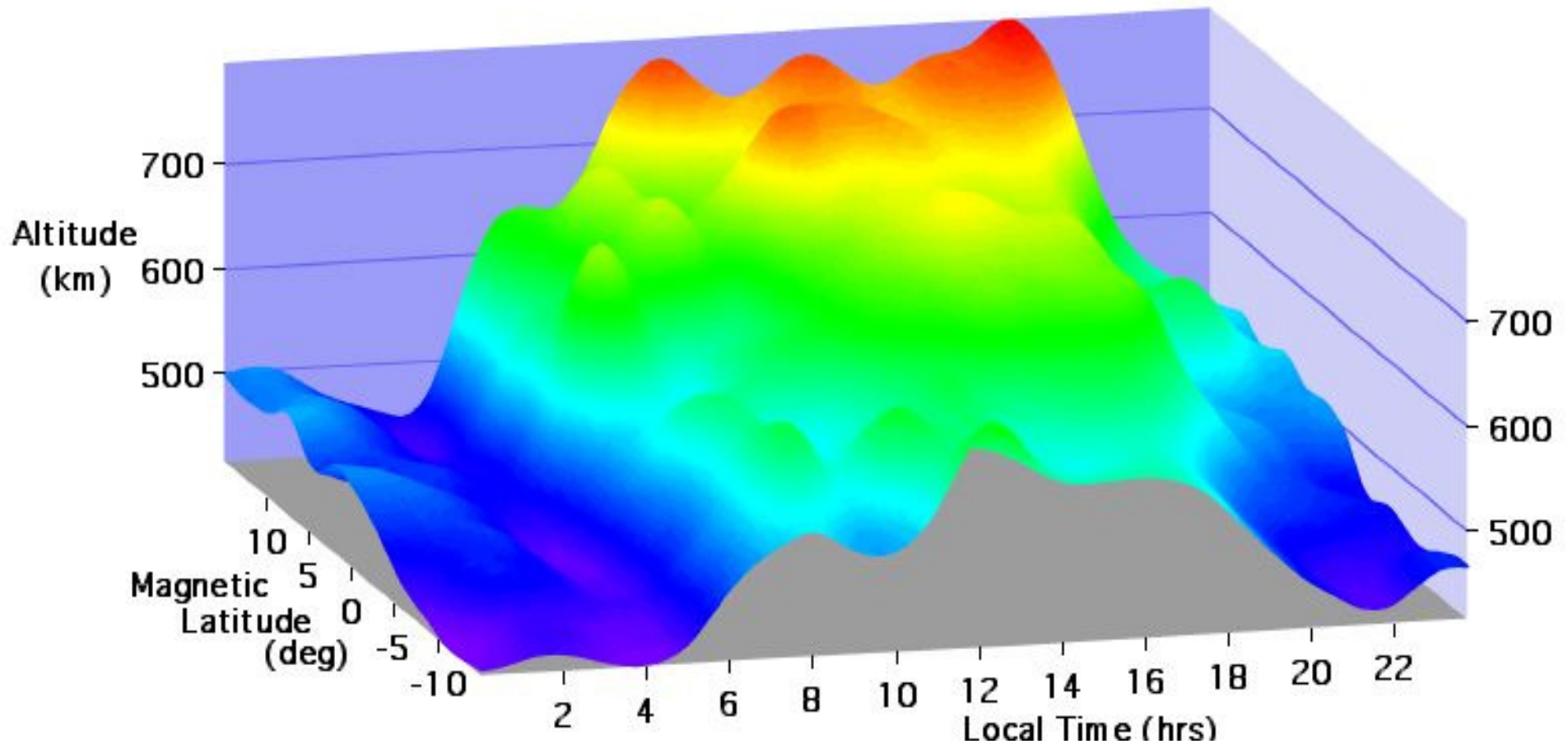


Prof. Roderick Heelis
CINDI Principal Investigator
The University of Texas at Dallas

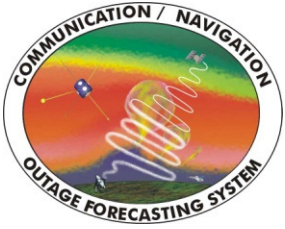




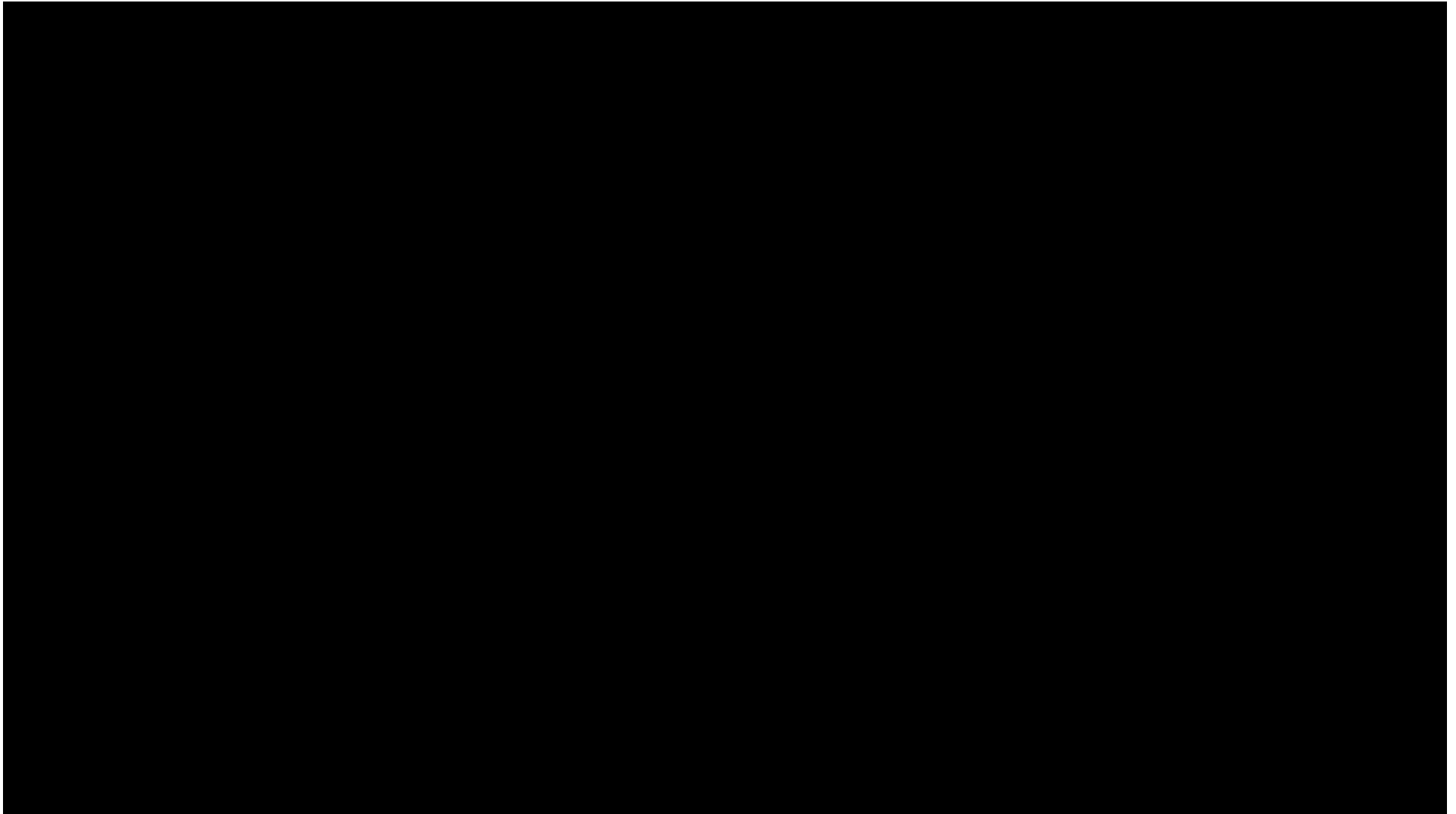
The Ionosphere at Solar Minimum

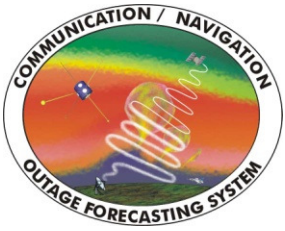


C/NOFS has observed the top of the ionosphere at solar minimum continuously for the first time. It is a surface that “breathes” - up during the day and down at night.



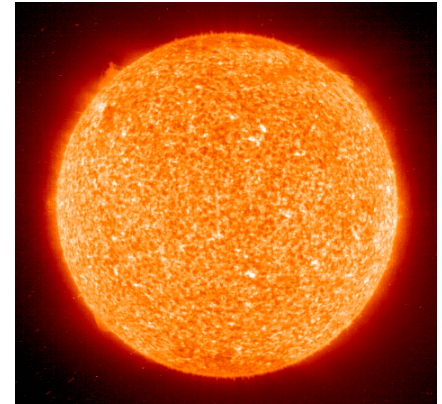
The Day and Night Ionosphere





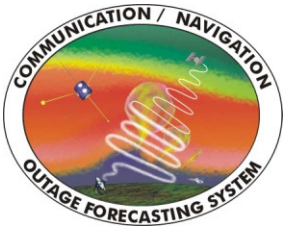
C/NOFS Preliminary Results

- **C/NOFS spacecraft is in a unique environment; solar EUV flux is at the lowest levels ever recorded!**
- **Height of the topside of the ionosphere is unexpectedly low.**
- **Altitude range of the ionospheric layer is also far lower than expected even at solar minimum.**

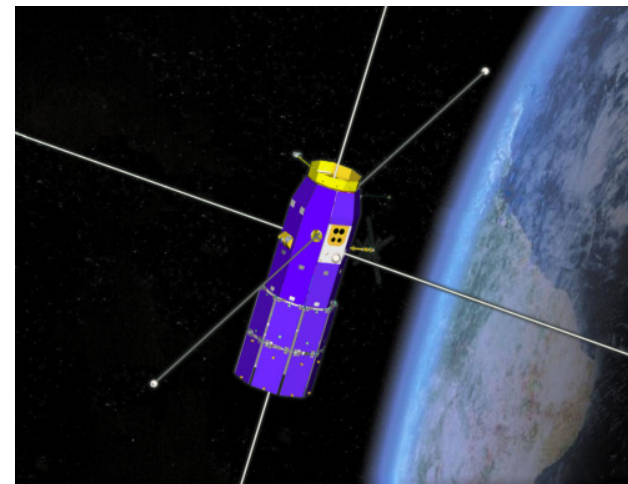
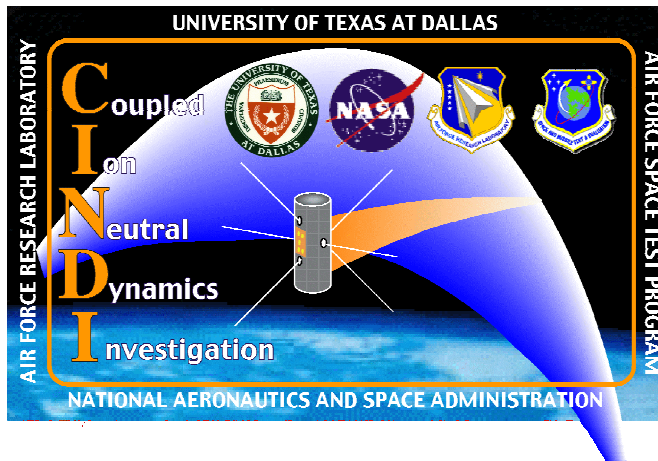


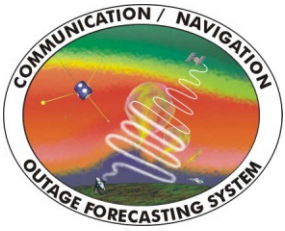
C/NOFS has provided a fundamental new image of our planet and its space environment.





Dr. Rob Pfaff
CINDI Project Scientist
VEFI Principal Investigator
National Aeronautics and Space Administration
Goddard Space Flight Center



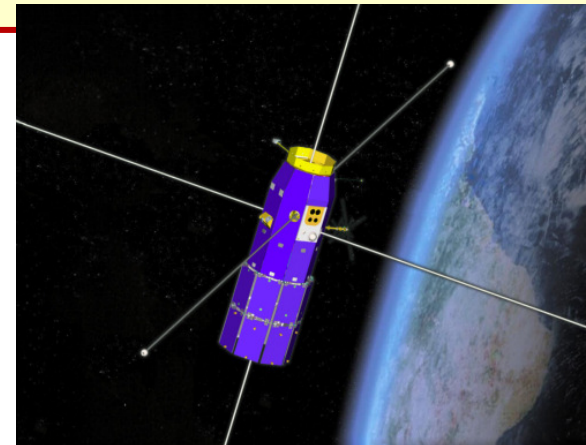


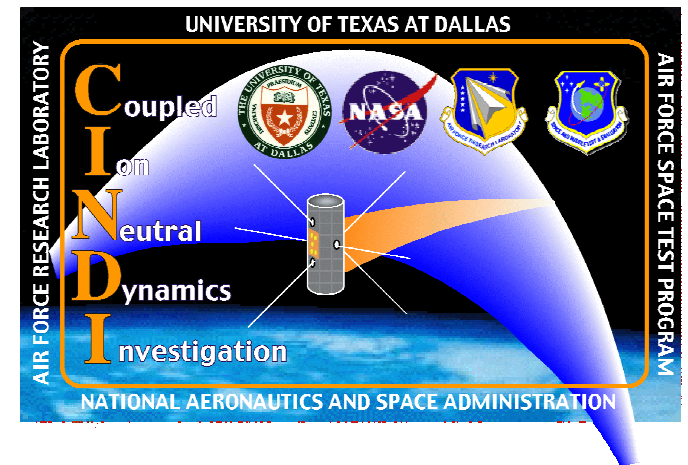
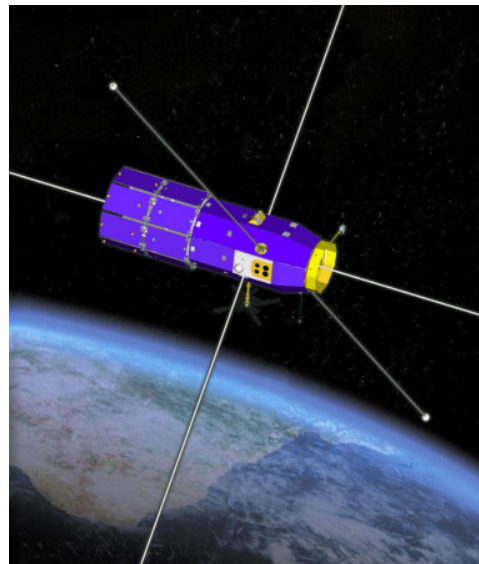
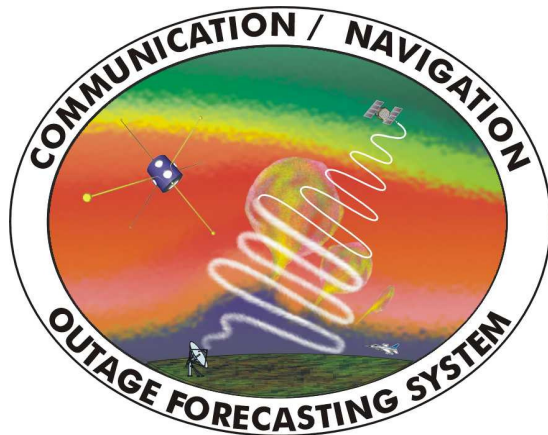
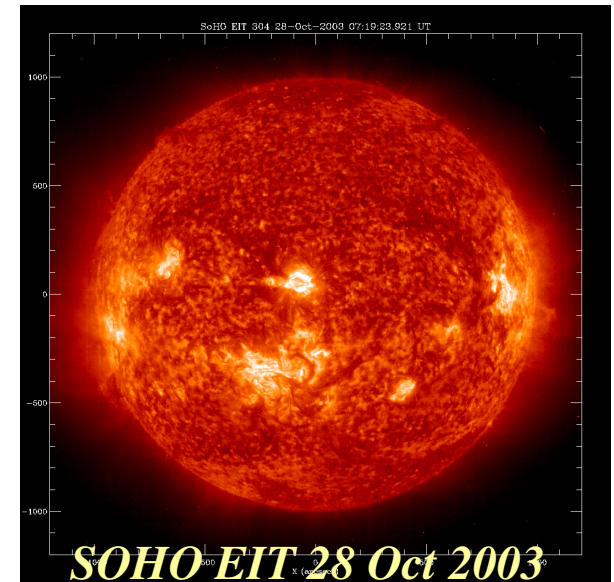
Communication / Navigation Outage Forecasting System

Communication /Navigation Outage Forecasting System

- Serves space weather applications and scientific research
- Provides fundamental new knowledge about Earth's ionosphere
- Presents first opportunity to forecast “space weather” in Earth's upper atmosphere
- Facilitates development of fully-integrated models and forecasts such as those currently used for tropospheric weather.

**More forecasting challenges lie
ahead as solar max approaches!**





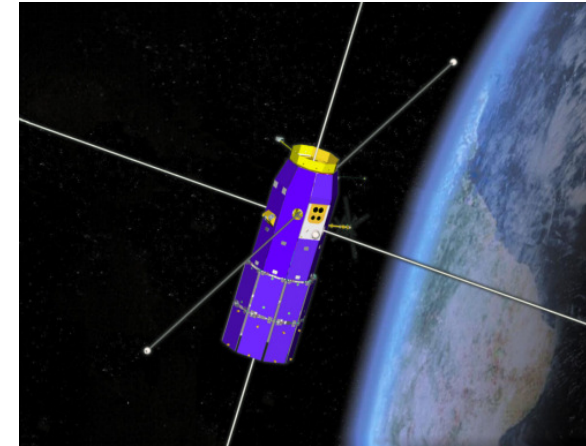
*All animations courtesy of NASA Goddard
Space Flight Center Conceptual Image Lab*



C/NOFS Satellite Instruments



- Equatorial orbit (~13° inclination; Apogee: ~867 km, Perigee: ~401 km)
- Objective: 72 – 120 hour forecast and specification of the ionosphere
- Instruments
 - **IVM: Ion Velocity Meter**
 - Ion drift velocity
 - Electron and ion temperatures
 - Electron density and density fluctuations
 - **NWM: Neutral Wind Monitor**
 - Vector neutral wind velocity
 - **PLP: Planar Langmuir Probe**
 - Ion density, electron temperature
 - **CORISS: GPS receiver**
 - Electron density
 - Scintillation, comm/nav outages
 - **CERTO: Radio beacon**
 - RF scintillation
 - **VEFI: Electric and magnetic field suite**
 - Electric field
 - Wave spectra
 - Plasma irregularities



CINDI: IVM and NWM

PI: Rod Heelis, Greg Earle, UTD

PLP

PI: Don Hunton, AFRL

CORISS

PI: Paul Straus, Aerospace

CERTO

PI: Paul Bernhardt, NRL

VEFI

PI: Rob Pfaff, NASA GSFC